DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

THE

BULLETIN

OF THE

BEACH EROSION BOARD

OFFICE, CHIEF OF ENGINEERS
WASHINGTON, D.C.

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DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

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BEACH EROSION BOARD

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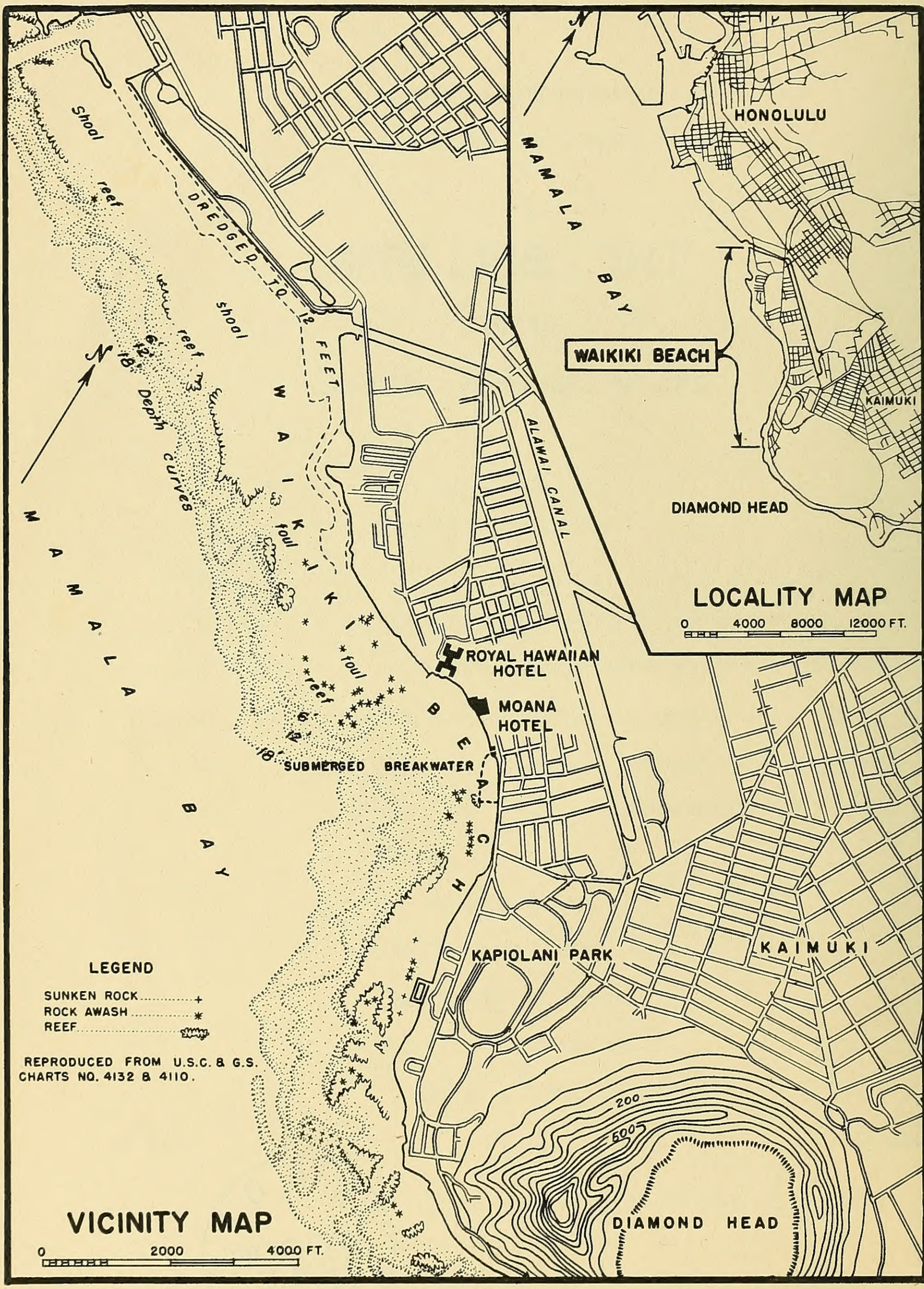


HONOLULU
MAMALA BAY
WAIKIKI BEACH
KAIMUKI
DIAMOND HEAD
LOCALITY MAP
0 4000 8000 12000 FT.
Shoal
reef
DREDGED TO 12 FEET
shoal
reef
6' 12' 18' Depth curves
WAIKIKI BEACH
foul
ALAWAI CANAL
ROYAL HAWAIIAN HOTEL
MOANA HOTEL
SUBMERGED BREAKWATER
MAMALA BAY
KAPIOLANI PARK
KAIMUKI
LEGEND
SUNKEN ROCK
ROCK AWASH
REEF
REPRODUCED FROM U.S.C. & G.S. CHARTS NO. 4132 & 4110.
200
600
DIAMOND HEAD
VICINITY MAP
0 2000 4000 FT.

FIGURE 1

AN ENGINEER LOOKS AT WAIKIKI BEACH

DONALD F. HORTON, ENGINEER
CHIEF, STUDIES AND REPORTS BRANCH, BEACH EROSION BOARD

An inspection of Waikiki Beach was made for the Beach Erosion Board by the writer on the request of the District Engineer, Honolulu, Hawaii during December 1947. This inspection afforded an opportunity to study the engineering features of this famous beach and to acquire background material for an outline of a study which would ultimately formulate a plan to improve the beach. Some of the features noted during the inspection are described and illustrated in this article.

Waikiki Beach is located on the south shore of the Island of Oahu between the business center of Honolulu and Diamond Head. Waikiki Beach (Figures 1, 2, 3, 4) is a narrow* beach chiefly composed of cream colored and light tan grains of worn coral, coralline algae, shells, and other calcareous marine organisms. The exact limits of Waikiki Beach are not defined, but the two-mile length centered on the Royal Hawaiian and Moana Hotels is most commonly referred to as "Waikiki Beach."

* Because buildings have been located close to the water line.

FIGURE 2. GENERAL VIEW OF WAIKIKI BEACH. MOANA HOTEL ON RIGHT, ROYAL HAWAIIAN HOTEL ON LEFT.

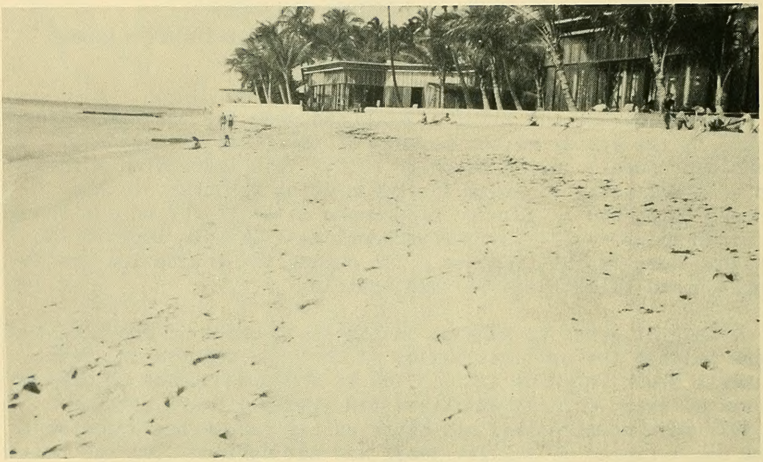


FIGURE 3. BEACH AND SEAWALL IN FRONT OF ROYAL HAWAIIAN HOTEL

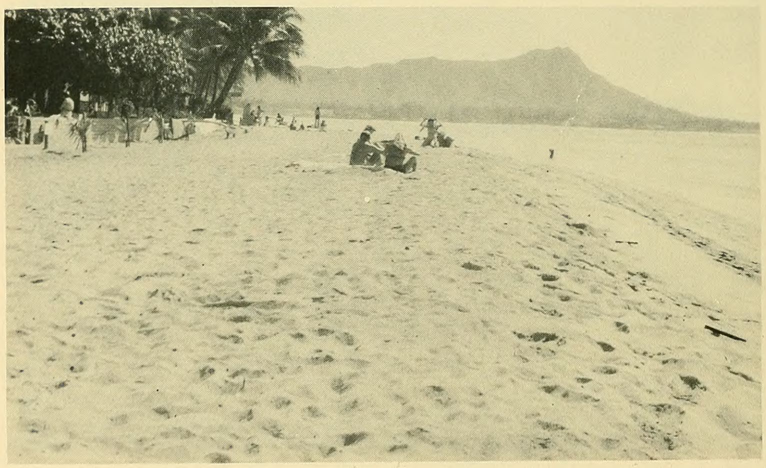


FIGURE 4. A TYPICAL SECTION OF THE BEACH. DIAMOND HEAD IN BACKGROUND.

Existing protective structures at Waikiki Beach consist of sea walls, (Figure 3) groins (Figure 5) and a short offshore breakwater. (Figure 7). The sea walls, of various types, extend along most of the length of the beach. The groins are short and, although of too light design to withstand heavy wave action, have suffered little damage over periods varying up to ten years.

The offshore breakwater is 700 feet long, 250 feet offshore, and cellular in type. It was constructed in 1938 of interlocking precast concrete slabs forming cribs which were filled with rock fragments and boulders to the top elevation of mean lower low water. At mean higher high water the breakwater is submerged about 2 feet. The area landward of the breakwater was cleared of coral patches by a dragline excavator and 7,000 cubic yards of sand obtained from a nearby municipally-owned beach park was placed artificially on the beach. As the project neared completion, it was apparent that the newly deposited sand tended to move northwesterly, and shore returns were constructed at each end of the breakwater to retain the sand in the inclosed area.

Figure 6 shows the condition of the beach opposite the site of the offshore breakwater prior to its construction and artificial placement of sand fill. Figure 7 shows this improvement

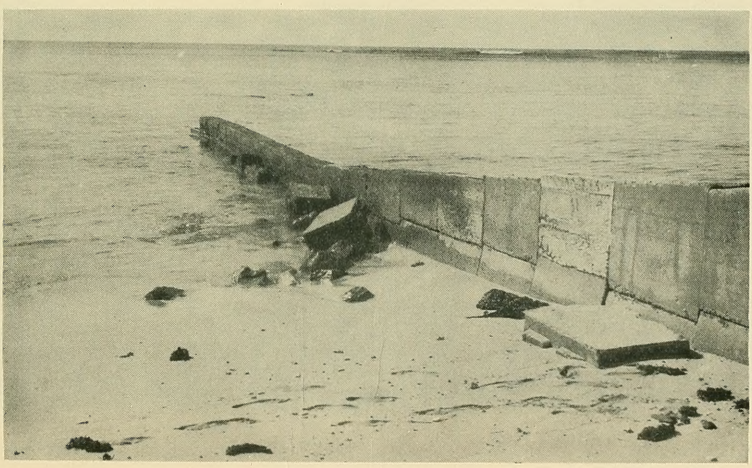


FIGURE 5. TYPICAL GROIN

FIGURE 6. PRIOR TO CONSTRUCTION OF SUBMERGED BREAKWATER AND ARTIFICIAL PLACEMENT OF SAND FILL, 1939.

FIGURE 7. AFTER CONSTRUCTION OF SUBMERGED BREAKWATER AND ARTIFICIAL PLACEMENT OF SAND FILL, 1939.

soon after completion. Figure 8 shows a portion of the same area in 1947. It is obvious from comparison of Figures 7 and 8 that there has been a considerable loss of sand fill from the beach in the 8 years since its artificial placement. The results are considered satisfactory, however, because favorable conditions resulting from the improvement have been experienced for nearly 10 years. This portion of the beach is now in better condition than it was in 1938 and the rate of deterioration is slow. In this case, as in most cases involving rehabilitation of a beach by artificial placement of material, it is to be expected that occasional replenishment of material will be necessary.

Waikiki Beach is fronted by a bench-like fringing coral reef at the edge of which waves break 1/4 to 1/2 mile from shore, creating the famous favorable conditions for surf riding. Waves breaking on the beach are ordinarily small in height. At the time of inspection, the breakers at the edge of the reef averaged 3 to 4 feet with occasional heights of 5 to 6 feet, while the waves breaking on the beach varied in height from a few inches to 1 foot. Although greater accumulations of sand on the south side of existing groins indicate predominant northwesterly littoral drift, at the time of inspection the waves were approaching the beach with crests nearly parallel to the water line and no alongshore movement of material was noted.

The mild and even climate (for example, 8 December 1947, minimum temperature 67° F, maximum temperature 78° F, relative humidity 68 per cent, wind northeast 10 miles per hour), the warm sea water (temperature range from about 70° F to 85° F) and wave action varying from breakers at the edge of the fringing reef to virtually calm water at the beach, make Waikiki Beach a very popular resort and an important attraction for visitors from the mainland.

During inspection a considerable spatial variation in grain size both laterally and longitudinally was noted. Patches of coral which exist within wading depths are considered objectionable by some visitors.

Local interests believe Waikiki Beach is slowly eroding. They wish not only to prevent further narrowing of the beach but also to widen the usable recreational area and to remove or cover coral patches within wading depth. They indicated an interest in initiating a cooperative beach erosion study for the purpose of determining the best method of providing the desired protection and improvement and the extent of Federal contribution toward the first cost thereof. Public interest is claimed to relate to the following:

a. The publicly-owned portions of the shore.

b. The public benefit to the Territory of Hawaii as a whole derived from tourists attracted to Waikiki Beach.

FIGURE 8. BEACH BEHIND OFFSHORE BREAKWATER, 1947

c. The desire of local interests for public ownership of any additional beach area that can be provided.

Preliminary analysis of available data indicate that the objectives desired by local interests can be accomplished by artificial placement of beach material. It will probably also be necessary to construct groins to retard the rate of loss of the artificially placed material. Further study is necessary to check the preliminary analysis, to determine the most practicable and economical source of artificial nourishment, to develop the best plan of improvement, and to determine the economic justification for the protection and improvement of the publicly-owned portions of the shore.

* * *

REVIEW OF SHALLOW WATER SURVEY METHODS

The Beach Erosion Board is responsible for coordinating the research and development and the application of methods of determining shallow water hydrography within the Corps of Engineers. As one step in filling this assignment a review of shallow water survey methods as presently or recently practiced in the civil works of the Corps of Engineers was undertaken. The purpose of the review is to obtain an overall picture of the survey practice and methods now in use by the Corps.

In order to accomplish the purpose a questionnaire was prepared by the Board and disseminated to all Districts throughout the Corps. The questionnaire provides for the division of a particular District's work load into comparable classes of survey conditions which have been selected on the basis of the technical or practical problems involved. The questionnaire also develops information as to the methods, techniques, personnel and equipment used, the number and spacing of soundings and the actual cost of the work per square mile. The specific survey conditions investigated are:

a. Slow Rivers (Maximum current velocity less than 3 feet per second with little or no tidal influence)

b. Medium Rivers (Maximum current velocity between 3 and 7 feet per second with little or no tidal influence)

c. Fast Rivers (Maximum current velocity over 7 feet per second with little or no tidal influence)

d. Slow Tidal Rivers and Inlets (Tidal currents predominate but are less than 3 feet per second at strength)

e. Medium Tidal Rivers and Inlets (Tidal currents predominate and are between 3 and 7 feet per second at strength)

f. Fast Tidal Rivers and Inlets (Tidal currents predominating and are greater than 7 feet per second at strength)

g. Calm Lakes, Reservoirs, and Ocean (Waves less than one foot high not occurring as breakers)

h. Active Lakes, Reservoirs and Ocean (Waves between one and 3 feet high not occurring as breakers)

i. Severe Lakes, Reservoirs, and Ocean (Waves 3 feet or more in height not occurring as breakers)

j. Shores and Shoals with low surf or breakers (Waves less than one foot high on breaking)

k. Shores and Shoals with medium surf or breakers (Waves between one and 3 feet high on breaking)

l. Shores and Shoals with severe surf or breakers (Waves over 3 feet high on breaking)

m. Ice covered lakes and rivers

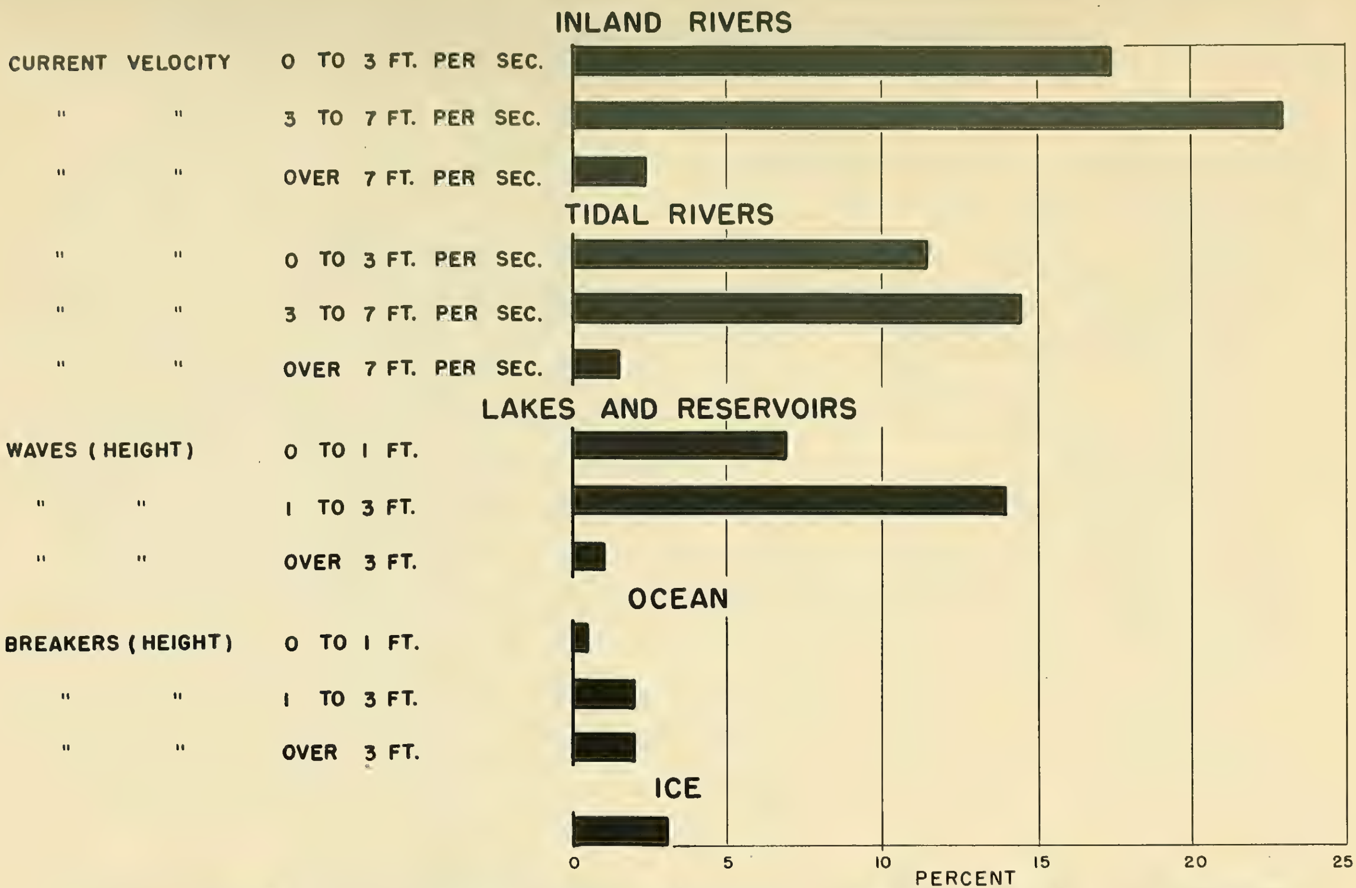
The data thus developed indicate that about 40 per cent of the shallow water surveys done by the various Districts consists of surveys made on slow and medium rivers (velocities from 0 to 3 feet per second and 3 to 7 feet per second, respectively; with little or no tidal influence). The approximate percentage of the total work load of all Districts for the rivers, lakes and oceans surveyed are shown in Figure 1.

The surveys usually are made to accomplish two general types of work. One is the general coverage work done in connection with preliminary examinations and similar type surveys; the other is the contract work done in connection with contract dredging. Two methods are employed generally in making the necessary surveys; the soundings are obtained by contact using a lead line to determine the depths, or by an echo sounder.

The data from the questionnaire show that throughout all Districts of the Corps water depths are determined by contact soundings in 75 per cent of all surveys and by echo sounder in the remaining 25 per cent. A further breakdown of the data shows:

No. of Districts	Percentage of Surveys made by Contact Method
20	100
6	75 - 100
6	50 - 25
7	25 - 0

The questionnaire develops the fact that the interval between soundings and the distance between ranges varies considerably for the surveys made by both methods. Table 1 lists average, maximum, and minimum sounding interval and range distance for all surveys. It is to be understood that the lines of soundings taken with the echo sounder are continuous, and the distances given in the table represent the interval at which spot soundings were taken from the record.



DISTRIBUTION OF SURVEYS FOR VARIOUS CONDITIONS—ALL DISTRICTS

FIG. 1

TABLE I

DISTANCES BETWEEN SOUNDINGS AND RANGES FOR ALL SURVEYS

Type of Survey and Method Used	Max. Dist. Between Ranges and Soundings		Ave. Dist. Between Ranges and Soundings		Min. Dist. Between Ranges and Soundings	
	Ranges	Sdgs.	Ranges	Sdgs.	Ranges	Sdgs.
Contract (Contact)	150	55	100	17	50	5
Contract (Echo Sounder)	1000	100	375	36	100	15
Gen. Cov. (Contact)	200	30	120	17	25	25
Gen. Cov. (Echo Sounder)	1000	100	400	38	75	20

A number of suggestions were made by the Districts as possible means of improving shallow water survey methods. The one most desired is a faster and more reliable method of positioning the boat and locating soundings. The other principal suggestions are as follows:

a. Use the echo sounder method instead of the contact method wherever practicable.

b. Develop an improved type fathometer.

c. Use some electronic device such as radar for location of a "fix."

d. Limit weight of equipment to one man loads if possible.

e. Use of close range radar equipment in survey work.

Further study of the data is in progress.

* * *

THEORETICAL STUDIES ON SURFACE GRAVITY WAVES

A group working in the Institute for Mathematics and Mechanics, New York University, under Navy contract N6ori-201 Task Order No. 1 has made theoretical studies of phenomena concerning surface gravity waves. Some of the results are reported in this series of papers.

"Waves over Beaches of Small Slope, Under a Dock, Under an Overhanging Cliff, and Past Plane Barriers," September 1947.

"The problem of obtaining two dimensional progressing waves over beaches with slope angle $\omega=\pi/2n$, n an integer, has been discussed recently by Bondi, Miche, Lewy, and Stoker. All of the solutions given by these authors become more complicated and cumbersome as n becomes larger, that is, as the beach slope becomes smaller. In fact, the solutions consist of finite sums of complex exponentials and exponential integrals, and the number of the terms in these sums increases with n. Actual ocean beaches usually slope rather gently, so that many of the interesting cases are just those in which the slope angle is small--of the order of a few degrees, say. K. O. Friedrichs has obtained a representation of thesolution of the problem for all n in the form of a single complex integral, which can in turn be treated by the saddle point method to yield asymptotic solutions valid for large n, that is for beaches with small slopes. The resulting asymptotic representation turns out to be rather simple-- even for numerical computations--and it appears to be very accurate. A comparison with the exact numerical solution for $\omega=6°$ shows the asymptotic solution to be practically identical with the exact solution all the way from infinity to within a distance of less than a wave length from the shore line.

H. Lewy has obtained progressing wave solutions over beaches with slope angles $\omega=p\pi/2n$, with p an odd integer such that $p<2n$. Thus the theory is available for cases in which ω is greater than $\pi/2$, so that the "beach" becomes an overhanging cliff. The solution for a special case of this kind, i.e. for $\omega = 135°$ or p = 3, n = 2, has been carried out numerically by E. Isaacson in a report now being reproduced. It turns out that there is at least one interesting contrast with the solutions for waves over beaches in which $\omega<\pi/2$. In the latter case it has been found that as a progressing wave moves in toward shore the amplitude first decreases to a value below the value at ∞ , before it increases and becomes very large at the shore line. The same thing holds for standing waves; At a certain distance from shore there exists always a crest which is lower than the crests at ∞ . In the case of the overhanging cliff with $\omega=135°$, however, the reverse is found to be true: The first maximum going outward from the shore line is about 1% higher than the

height of the crest at ∞. Still another fact regarding the behavior of the solutions near the shore line is interesting. In all cases there exists just one standing wave solution which has a finite amplitude at the shore line; H. Lewy has shown that the ratio of the amplitude there to the amplitude at ∞ is given in terms of the angle ω by the formula $\sqrt{\pi/2\omega}$. Thus for angles ω less than $\pi/2$ the amplitude of the standing wave with finite amplitude is greater on shore than it is at infinity (becoming very large as ω becomes small) while for angles ω greater than $\pi/2$ the amplitude on shore is less than at ∞. This result has been verified by E. Isaacson for the special case $\omega = 3\pi/4$. Since the observations indicate that the standing wave of finite amplitude is likely to be the wave which actually occurs in nature for angles ω greater than about 40°, the above results can be used to give a rational explanation for what might be called the "wine glass" effect: Wine is much more apt to spill over the edge of a glass with an edge which is flared outward than from a glass with an edge turned over slightly toward the inside of the glass.

A limit case of the problem of the overhanging cliff has a special interest, namely the case in which ω approaches the value π and the problem becomes what might be called the "dock problem": The water surface is free up to a certain point but from there on it is covered by a rigid horizontal plane. The solutions given by Lewy are so complicated as p and n become large that it seems hopeless to consider the limit of his solutions as $\omega \to \pi$. Friedrichs and Lewy have, however, attacked and solved the dock problem directly. Their results will appear shortly.

A fourth report by F. John deals with the effect of a plane rigid barrier on the surface waves in water which is, apart from the barrier, everywhere infinite in depth. The barrier is assumed to be inclined at an angle $\pi/2n$, n an integer, to the horizontal and to extend in the one case from the surface down into the water for a finite distance and in the other case to extend from infinity up to a point a certain finite distance below the water surface. The special case of vertical barrier has been treated by F. Ursell by a method different from that used by F. John, but which does not yield all possible solutions behaving like the classical steady progressing wave solutions at infinity. One of the interesting results obtained by F. John is the following: Consider first the case of a plane barrier extending from a point below the water surface down to infinity. If it is prescribed that a progressing wave of fixed amplitude and frequency comes in from the right hand infinity, say, and that a progressing wave of the same frequency but unknown amplitude goes past the barrier to the left hand infinity while another is reflected back to the right hand infinity, it turns out that the problem has a uniquely determined solution provided that quite reasonable assumptions are made about the singularity at the tip of the barrier. In other words, a uniquely determined "reflection coefficient" for the barrier is obtained in this case simply by

stipulating that there should be no progressing wave coming toward the barrier from the left hand infinity. However, in the case of a barrier extending from the surface downward a finite distance the situation is quite different in this respect. No uniquely defined reflection coefficient can be determined because of the fact that the strength of the singularity at the intersection of the barrier with the water surface cannot be determined a priori. This fact was observed earlier in dealing with a similar problem for waves on sloping beaches; the fact is that one would probably have to utilize knowledge of some sort about the phenomena of breaking of waves--which are essentially non-linear phenomena and hence out of the scope of the theory in question here--in order to determine reflection coefficients in these cases without recourse to experimental results. The results of observations (cf. the paper of Miche) on sloping beaches seem to indicate the following to be likely: If a barrier slopes at a small angle then practically all the energy of a progressing wave moving in the direction of decreasing depth over the barrier will be converted either into heat or into the energy of a flow (the undertow) through the occurrance of breakers. If however, the wave amplitude is very small or the slope angle is large enough (greater than 40°, according to Miche) a standing wave, denoting perfect reflection, will be observed over the barrier in practice."

"Waves Against a Cliff Overhanging at an Angle of 135°, Eugene Isaacson, September 1947.

Lewy's method is applied to treat numerically waves progressing against a cliff overhanging at 135°. The nature of the waves are analyzed by computing the shape of the two fundamental waves φ_0 and φ_1, from which all progressive wave solutions can be constructed. The principal results are: At shore the amplitude damping effect of the cliff is about 3 per cent shorter, and beyond one wave length from the shore the effect of the cliff is negligible.

"Theory of Underwater Explosion Bubbles," Bernard Friedman, September 1947.

This paper supplements and greatly extends previous work on underwater explosions, in particular AMP Report 37.1R, "Studies on the Gas Bubble Resulting from Underwater Explosions: On the Best Location of a Mine Near the Sea Bed," by the author and Max Shiffman. Here is shown that the effects of surface, bottoms, walls, target, etc., can be approximated by the addition of a suitable term to the kinetic energy. The evaluation depends upon the solution of an "electrostatic problem." Section IV develops in detail the case of a bubble between a free surface and a bottom. Section I presents a collection of formulas and a summary of methods which can be used to predict the period of oscillation of the bubble, the distance its center moves, during the first oscillation, the maximum and minimum radius of the bubble, and finally, the peak pressure emitted by the bubble. The formulas

are given in the form of certain integrals which were evaluated by the method given in AMP Report 37.1R. Graphs of these integrals for the most frequently occurring values of the parameters are included. Section III contains a discussion of these formulas and a short indication of their proof. A careful analysis is made of the dependence of the parameters in the bubble motion upon the properties of the explosive in Section II the theory is applied to the analysis of some experimental data obtained at Woods Hole by Arons and his co-workers. It is stated that the agreement between theory and experiment as regards period is excellent; as regards pressure and distance the bubble moves, the agreement is only fair. The problem is idealized by assuming that (1) water is an ideal incompressible fluid, (2) the bubble remains spherical in shape, and (3) the gas inside the bubble expands adiabatically.

"The Dock Problem," K. O. Friedrichs and Hans Lewy, October 1947.

"Suppose one half-plane of an infinite water surface is covered with a rigid plate, the "dock". How does the dock influence waves standing or traveling perpendicularly to the edge of the dock on a free water surface?" A solution is presented based on a method related to the La Place transformation. It is stated that the problem permits a simple explicit solution which offers the possibility of discussing the nature of the solution and of determining it numerically. The behavior of the wave motion near the edge of the dock, i.e. near the line along which the water surface and the dock meet is discussed. The amplitudes of the waves on a free surface and the pressure under the dock are shown graphically. It is said that aside from its interest as a flow problem, the dock problem is of significance as a new example of a potential problem with different linear boundary conditions on different parts of the boundary.

"Water Waves on a Shallow Sloping Beach," K. O. Friedrichs, October 1947.

It is stated that the problem of standing and progressive waves on a beach with a plane bottom has been solved by Miche, Lewy and Stoker for slope angles ω which are integral fractions of a right angle, $\omega = \pi/2n$, n = 1, 2,.... In this report, in which various suggestions by J. J. Stoker and H. Lewy are incorporated, a simple asymptotic representation for small angles ω is presented. It is shown that for small slope angles the flow can be described as consisting of waves with a varying wave length, which depend on the depth in the same way as Airy's waves in channels with constant depth. Formulas are developed which give the dependence of the amplitude and the phase on the depth for small slope angles. It is said that the wave shape calculated on the basis of developed formulas for a beach with a 6° slope agree almost perfectly with the calculated on the basis of the

exact theory.

"Waves in the Presence of An Inclined Barrier," Fritz John, November 1947.

This paper deals with the motion of water of infinite depth in the presence of a fixed barrier of length A which extends downward from the surface and forms an angle $\pi/2n$ with the horizontal direction where n is the positive integer. It is based on the work of J. J. Stoker and H. Lewy for determining waves on sloping beaches, "Waves over Beaches of Small Slope, Under a Dock, Under an Overhanging Cliff, and Past Plane Barriers," (IMM,NYU,161). By the use of complex functions the determination of the motion is reduced to the solution of an ordinary differential equation with constant coefficients instead of an integral equation. The role of the various physical assumptions in uniquely determining the solution is brought out clearly, and assumptions that have to be made to make Fourier integral transformations valid, are avoided. The paper treats the following: (1) the method for finding the general solution, (2) the case of a vertical barrier, (3) the submerged infinite barrier, (4) asymptotic behavior of exponential integrals, (5) derivation of the complete system of conditions on the general solutions for the inclined barrier, (6) the complete finite system of conditions for the solution, and (7) a uniqueness theorem.

"The Solitary Wave and Periodic Waves in Shallow Water," Joseph B. Keller, December 1947.

The paper states that the object of the present investigation is to discuss waves of permanent type in shallow water by a method in which the character of the approximation is quite clear, and which is capable of being carried out to include terms of any desired order. Actually stationary solutions are found; progressive waves may be obtained from them by adding a constant velocity to the fluid. The method consists in expanding the solution of the exact hydrodynamic problem systematically in powers of a dimensionless parameter $\sigma = \omega h$ where h is the depth of the undisturbed fluid and ω is the curvature at some point on the surface. The expansions are inserted into the equation of motion and the boundary conditions, and coefficients of like powers of σ are equated. The variables are chosen in such a way that the terms of zero order in the expansion in powers of σ satisfy the well-known equations of the nonlinear shallow water theory, which are analogous to the equations of gas dynamics. The derivation of these equations were attributed to the work of K. O. Friedrichs.

It is stated that it is easily shown that the only solutions of these equations for the first approximation (satisfied by the terms independent of σ) which are of permanent form are the constant or piecewise constant (shock type) solutions. However,

the equations for the second approximation (satisfied by the coefficients of σ) have solutions which yield periodic waves of permanent form, similar to those of Korteweg and DeVries, and also solitary waves, similar to those of Rayleigh and Boussinesq.

The solution of permanent form, as given by the first and second approximations, for the irrotational, two-dimensional motion of an incompressible, inviscid fluid of, mean depth h over a horizontal bottom is developed.

* * *

BEACH EROSION STUDIES

The principal types of beach erosion reports of studies at specific localities are the following:

a. Cooperative studies (authorization by the Chief of Engineers in accordance with Section 2, River and Harbor Act approved on 3 July 1930).

b. Preliminary examinations and surveys (Congressional authorization by reference to locality by name).

c. Reports on shore line changes which may result from improvements of the entrance at the mouths of rivers and inlets (Section 5, Public Law No. 409, 74th Congress).

d. Reports on shore protection of Federal property (authorization by the Chief of Engineers).

Of these types of studies, cooperative beach erosion studies are the type most frequently made when a community desires investigation of its particular problem. As these studies have, consequently, greater general interests, information concerning studies of specific localities contained in those quarterly bulletins will be confined to cooperative studies. Information about other types of studies can be obtained upon inquiry to this office.

Cooperative studies of beach erosion are studies made by the Corps of Engineers in cooperation with appropriate agencies of the various States by authority of Section 2 of the River and Harbor Act approved on 3 July 1930. By executive ruling the cost of these studies is divided equally between the United States and the cooperating agency. Information concerning the initiation of a cooperative study may be obtained from any District Engineer of the Corps of Engineers. After a report on a cooperative study has been transmitted to Congress, a summary thereof will be included in the next issue of this bulletin. Lists of cooperative studies completed since the last issue of the Bulletin and those now in progress follow:

COOPERATIVE STUDIES COMPLETED SINCE LAST ISSUE OF BULLETIN

MISSISSIPPI

HARRISON COUNTY. Completed 16 February 1948. Cooperating Agency: Harrison County Board of Supervisors.

Report has not been transmitted to Congress, but the following information has been released: "The Beach Erosion Board

endorsed Federal participation in the project to improve and protect the shore line. The report of the District Engineer dealt with the construction of a protective beach in front of the sea wall, with local interests undertaking construction of a drainage system for the wall and repairs to the wall itself. The Beach Erosion Board recommended that the Federal government contribute to the improvement to the extent of one-third of the original cost of the sea wall."

OHIO

CLEVELAND AND LAKEWOOD. Completed 22 March 1948. Cooperating Agency: City of Cleveland.

Report has not been transmitted to Congress, but the following information has been released: "The Beach Erosion Board endorsed Federal participation in the project to improve the beaches at Edgewater Park and White City Park. The report of the District Engineer dealt with the construction of groins and a cut-off wall, placement of sand fill and redistribution of sand. The Beach Erosion Board recommended that the Federal government contribute to the improvement of the extent of one-third of the cost of such work."

COOPERATIVE BEACH EROSION STUDIES IN PROGRESS

NEW HAMPSHIRE

HAMPTON BEACH. Cooperating Agency: New Hampshire Shore and Beach Preservation and Development Commission.

Problem: To determine the best methods of preventing further erosion and of stabilizing and restoring the beaches; also to determine the extent of silting and erosion in the harbor.

MASSACHUSETTS

METROPOLITAN DISTRICT BEACHES, BOSTON. Cooperating Agency: Metropolitan District Commission (for the Commonwealth of Massachusetts).

Problem: To determine the best methods of preventing further erosion, of stabilizing and improving the beaches, and of protecting the sea walls of Lynn Shore Reservation, Nahant Beach Parkway, Revere Beach, Quincy Shore, and Nantasket Beach.

SALISBURY BEACH. Cooperating Agency: Department of Public Works (for the Commonwealth of Massachusetts).

Problem: To determine the best methods of preventing further beach erosion. This will be a final report to report dated 26 August 1941.

RHODE ISLAND

STATE OF RHODE ISLAND. Cooperating Agency: State of Rhode Island (Acting through Rhode Island Department of Public Works).

Problem: To determine the best method of restoring and protecting shore lines against damage from storms and hurricanes on the south shore of Rhode Island from Clump Rocks east of the mouth of the Pettasquamscutt River to the Connecticut State Line.

CONNECTICUT

STATE OF CONNECTICUT. Cooperating Agency: State of Connecticut (Acting through the Flood Control and Water Policy Commission).

Problem: To determine the most suitable methods of stabilizing and improving the shore line. Sections of the coast will be studied in order of priority as requested by the cooperating agency until the entire coast is included.

NEW JERSEY

ATLANTIC CITY. Cooperating Agency: City of Atlantic City.

Problem: To determine the best methods of preventing further beach erosion.

VIRGINIA

COLONIAL BEACH. Cooperating Agency: Department of Highways (for the Commonwealth of Virginia).

Problem: To formulate a master plan for the improvement of the beach and to determine the best method of arresting erosion of the bank adjacent to the State Highway at Colonial Beach.

VIRGINIA BEACH. Cooperating Agency: Town of Virginia Beach.

Problem: To determine methods for the improvement and protection of the beach and existing concrete sea wall.

LOUISIANA

LAKE PONTCHARTRAIN. Cooperating Agency: Board of Levee Commissioners, Orleans Levee District.

Problem: To determine the best method of effecting necessary repairs to the existing sea wall and the desirability of building an artificial beach to provide protection to the wall and also to provide additional recreational beach area.

TEXAS

GALVESTON COUNTY. Cooperating Agency: County Commissioners Court of Galveston County.

Problem: To determine the best method of providing a permanent beach and the necessity for further protection or extending the sea wall within the area bounded by the Galveston South Jetty and Eight Mile Road.

CALIFORNIA

STATE OF CALIFORNIA. Cooperating Agency: Division of Beaches and Parks, State of California.

Problem: To conduct a study of the problems of beach erosion and shore protection along the entire coast of California. The initial studies are to be made in the Ventura-Port Hueneme area and the Santa Monica area.

ILLINOIS

STATE OF ILLINOIS. Cooperating Agency: Department of Public Works and Buildings, Division of Waterways, State of Illinois.

Problem: To determine the best method of preventing further erosion and of protecting the Lake Michigan shore line within the Illinois boundaries.

OHIO

STATE OF OHIO. Cooperating Agency: State of Ohio (Acting through the Superintendent of Public Works).

Problem: To determine the best method of preventing further erosion of and stabilizing existing beaches, of restoring and creating new beaches, and appropriate locations for the development of recreational facilities by the State along the Lake Erie shore line.

PENNSYLVANIA

PRESQUE ISLE. Cooperating Agency: State Parks and Harbor Commission of Erie (for the Commonwealth of Pennsylvania).

Problem: To determine the best method of preventing further erosion and stabilizing the beaches of Presque Isle Peninsula at Erie, Pennsylvania. This will be a supplemental report to the report dated 3 April 1942.

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BEACH EROSION LITERATURE

There are listed below some recent acquisitions of the Board's library which are considered to be of general interest. Copies of these publications can be obtained on 30 day loan by field offices of the Corps of Engineers and other Government agencies.

"The Rate of Rounding of Beach Boulders," J. A. Bartrum, Journal of Geology, Chicago, Illinois, v. 55, no. 6, pp. 514-515, November 1947.

"A demonstration is given of the ability of waves of moderate strength to round blocks of hard fine grained basalt as much as 2 feet in diameter in less than 10 years. Mention is also made of an example of the short distance of travel that may be involved in the rounding of stream pebbles."

"Hawaiian Swell From January 2-5, 1947," R. S. Arthur, Scripps Institution of Oceanography Wave Report No. 72, La Jolla, Cal., 7p, illus., November 26, 1947.

The report describes the 20 to 40 feet high waves which damaged the northern shores of the Hawaiian Islands from January 2-5, 1947. It demonstrates that since even such extreme wave conditions are entirely due to wind, they can be forecast using techniques already in existence. In this case Kahului Harbor is used as an example.

"The Refraction of Surface Waves by Currents," J. W. Johnson, Transactions American Geophysical Union, Washington, D. C., v. 28, no. 6, pp.867-874, December 1947, illus.

It is stated that when ocean waves moving through deep still water, encounter a current, moving at an angle with the wave direction, the waves undergo a change in length, steepness, and direction of travel. A theoretical development is given for these factors in terms of initial wave length and direction and the magnitude of the current. The action of coastal currents in affording protection against short period waves is discussed.

"The Formation of Beach Cusps," Ph. H. Kuenen, Journal of Geology, Chicago, Illinois, v. 56, no. 1, pp. 34-40, January 1948, illus.

"In former attempts to explain the development of beach cusps, stress has been laid on the erosion of the beach. It is argued in this paper that concomitant deposition on the horns is at least equally important. Refraction of the swash in building the cusps is emphasized, and an attempt is made to explain the rhythmic, roughly equidimensional nature of cusps."